Air Quality Effects of Trap-Related Emissions

(Updated)

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California Environmental Protection Agency

Air Resources Board

Acknowledgements

- Professor Donald Dabdub *(University of California at Irvine)*
- South Coast Air Quality Management District

Presentation Overview

- Summary of Previous (Preliminary) Analysis
- What's New
- Health Effects & Updated Air Quality Impacts
- Corroborative Analyses
- Summary and Conclusions

Summary of Previous Analysis

- Emission Assumptions:
  - 100% penetration of passive traps
  - 50% diesel NO_2 (NO_x mass unchanged)
  - Sensitivity analyses for aldehydes and VOCs
- Modeling:
  - Summer episode for southern California only
  - No PM modeling

Summary of Previous Analysis
(cont.)

- Results:
  - Ozone:
    - 4-7% increase in high ozone areas (11 ppb max.)
    - Zero diesel aldehydes reduces max. increase to 9 ppb
    - Zero diesel NMHCs reduces max. increase to 6 ppb
  - NO_2:
    - ~22% increase in one small area
    - ~5% increase in other areas
    - Remains below health-based standard

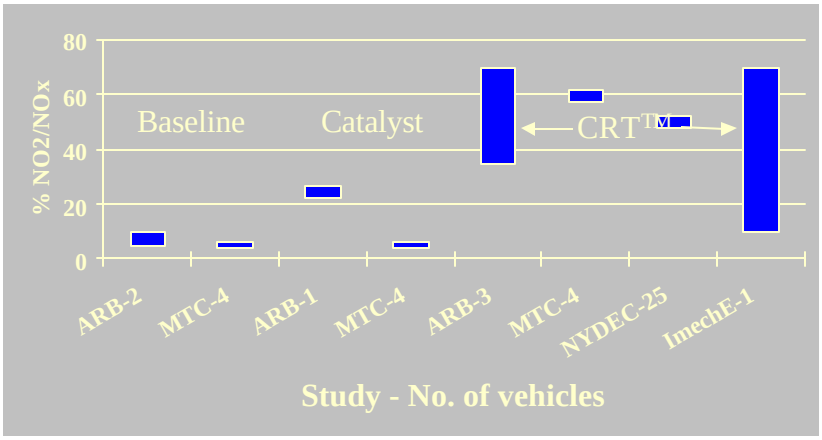
Summary of Previous Analysis
(cont.)

- Results *(cont.)*:
  - Nitric acid (24-hour):
    - 6-12% increase (1.7 ppb)
  - Nitric-acid derived PM (24-hour):
    - ~5.5 $\mu g/m^3$ increase
- Conclusion:
  - Potentially significant air quality disbenefits associated with traps

What's New?

Summary of Diesel NO_2/NO_x Studies

- In a catalyst plus soot filter system, the conversion of NO to NO_2 is a function of both exhaust temperature and fuel sulfur content.



What's New?

Exhaust Emissions

- Exhaust Emissions:
  - 90% penetration of passive traps
  - NO_x speciation changes considered:

	NO	NO_2	HONO
Baseline: NO_2=10%	88%	10%	2%
NO_2=15%	83%	15%	2%
NO_2=20%	78%	20%	2%
NO_2=25%	73%	25%	2%
NO_2=30%	68%	30%	2%
NO_2=50%	48%	50%	2%

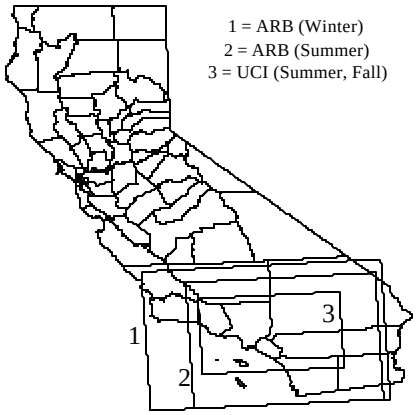
What's New?
Exhaust Emissions (cont.)

- Exhaust emissions *(cont.)*:
  - Other assumed emission reductions:

	% Reduction	Study
CO	90%	various
Total PM	85%	various
Total HCs	90%	various
Total carbonyls	90%	MTC
Formaldehyde	93%	MTC
Acetaldehyde	82%	MTC
Benzene	77%	ARB
Total PAHs	80%	NYDEC
nitro-PAHs	95%	NYDEC

What's New?
Episodes Simulated

- Summer (August), Fall (October), and Winter (~January) episodes for southern California



Emissions in Southern California

(Summer 2010 Episode, TPD)

		Baseline	With Passive Traps		
	Diesel NO_2/NO_x	10%	15%	30%	50%
ALL SOURCES	NO_x	1,579	1,579	1,579	1,579
	NO	906	888	833	762
	NO_2	**158**	**186**	**269**	**379**
	HONO	32	32	32	32
	CO	6,092	5,953	5,953	5,953
	Biogenic ROG	892	892	892	892
	Anthro. ROG	1,257	1,224	1,224	1,224
Diesels	NO_x	613	613	613	613
	NO_2	**61**	**89**	**172**	**282**
	CO	172	31	31	31
	ROG	42	8	8	8

Emissions in Southern California

(Winter 2010 Episode, TPD)

		Baseline	With Passive Traps		
	Diesel NO_2/NO_x	10%	15%	30%	50%
ALL SOURCES	NO_x	1,295	1,295	1,295	1,295
	NO	743	726	674	606
	NO_2	**130**	**156**	**235**	**340**
	HONO	26	26	26	26
	$PM_{2.5}$	**263**	**244**	**244**	**244**
	CO	4,883	4,768	4,768	4,768
	Biogenic ROG	290	290	290	290
	Anthro. ROG	1,019	988	988	988
Diesels	NO_x	583	583	583	583
	NO_2	**58**	**85**	**163**	**268**
	$PM_{2.5}$	**24**	**5**	**5**	**5**
	CO	158	30	30	30
	ROG	39	7	7	7

Air Quality Impacts
Pollutants and Air Quality Indicators

Pollutants

- Ozone *(Summer)*
- Nitric Acid *(Summer)*
- NO_2 (*Winter*)
- $PM_{2.5}$ *(Summer, Fall)*

Air Quality Indicators

- Change in peak value
- Cumulative 24-hour population exposure:

$$\sum_{24\text{ hours}} \frac{\sum_{\text{All cells}} (\text{Concentration} - \text{Threshold})(\text{Cell population})}{\sum(\text{Population in cells above the threshold})}$$

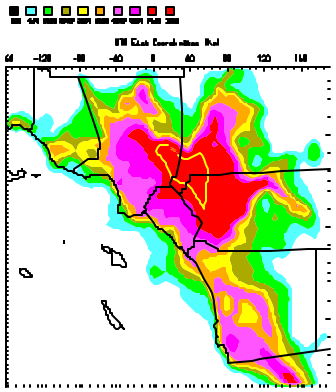
Air Quality Impacts
Ozone - Health Effects

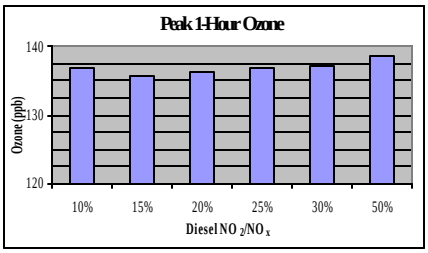
- Current standards:
  - State: 0.09 ppm (90 ppb) for 1-hour average
  - National: 0.12 ppm (120 ppb) for 1-hour average

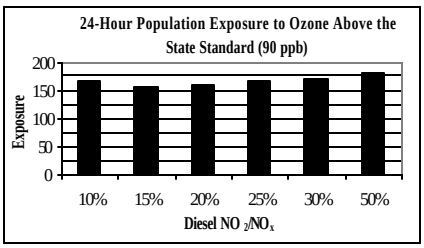
- Mainly acute effects at and below the standard:
  - airway inflammation
  - cough
  - chest tightness
  - reduced pulmonary function
  - increased respiratory symptoms
  - may cause and exacerbate asthma

Air Quality Impacts
2010 Summer Ozone

Peak 1-Hour Ozone *(Baseline)*





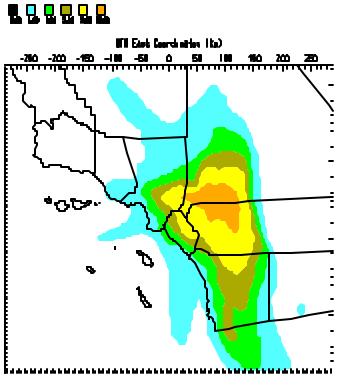


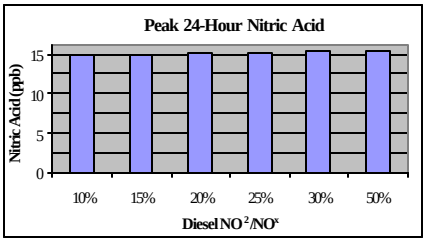
Air Quality Impacts
Nitric Acid - Health and Welfare Effects

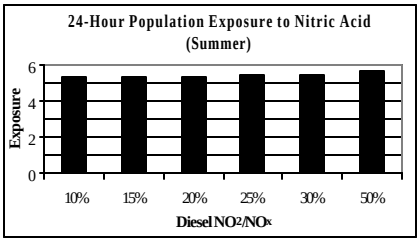
- No standard
  - 1-hour peaks typically 30 ppb or less
- Short-term exposure:
  - No apparent acute health risk with exposure to ambient concentrations
- Long-term exposure:
  - Effects unclear
  - Possible association with decreased lung function growth in children
- Welfare effects:
  - Nitrogen loading of pristine lakes and forest soils

Air Quality Impacts
2010 Summer Nitric Acid

Peak 24-Hour Nitric Acid *(Baseline)*





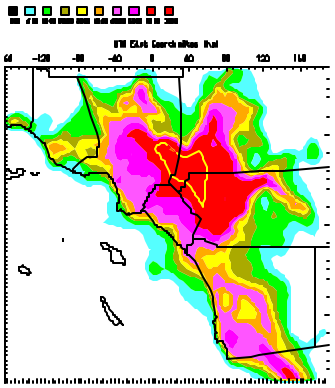


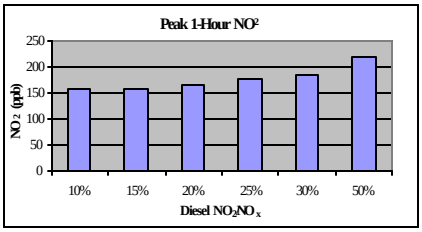
Air Quality Impacts
NO_2 - Health Effects

- Current standard:
  - State: 0.25 ppm (250 ppb) for 1-hour average
- Short and long-term exposures at concentrations at and below the standard:
  - Mortality
  - Respiratory symptoms
  - Respiratory illness
  - Reduced lung function
- May exacerbate asthma at concentrations at or below the standard

Air Quality Impacts
2010 Winter NO_2

Peak 1-Hour NO_2 *(Baseline)*





1-Hr NO2 standard = 250 ppb

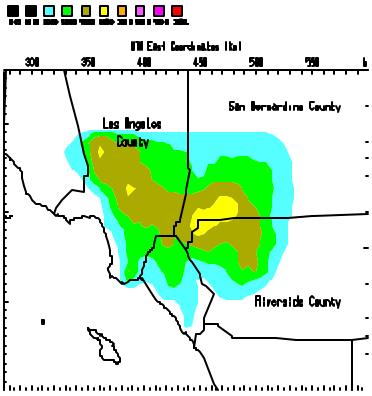
NO_2 Exposure = 0 *(all model estimates less than the standard)*

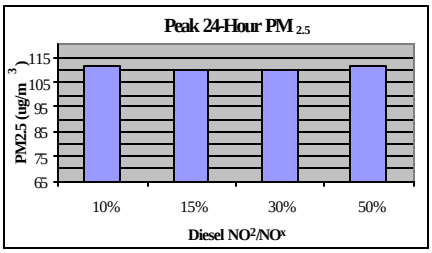
Air Quality Impacts
$PM_{2.5}$ - Health Effects

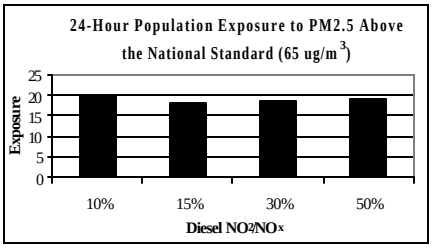
- Current standard:
  - National: 65 µg/m³ for 24-hour average
- Short and long-term exposures at concentrations at and below the standard:
  - Increased mortality
  - Increased hospital admissions
  - Respiratory illness
  - Asthma exacerbation
  - Reduced lung function
  - Respiratory symptoms
- Diesel PM (~90-95% $PM_{2.5}$)
  - Identified as a toxic air contaminant
  - Previous studies have shown that diesel PM contributes ~70% of known ambient cancer risk in southern California

Air Quality Impacts
2010 Summer $PM_{2.5}$

Peak 24-Hour $PM_{2.5}$ *(Baseline)*

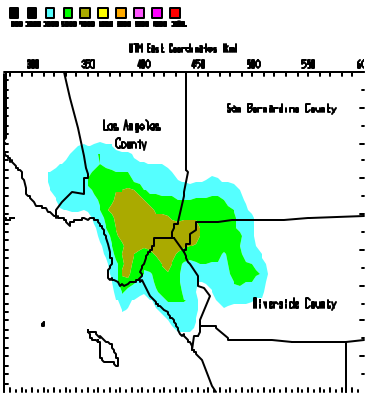


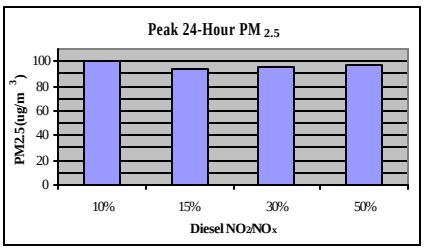


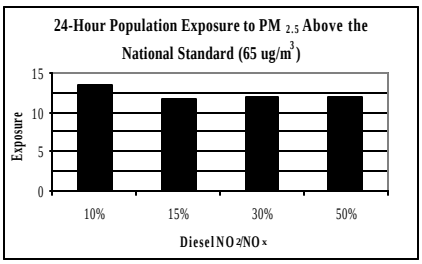


Air Quality Impacts
2010 Fall $PM_{2.5}$

Peak 24-Hour $PM_{2.5}$ *(Baseline)*





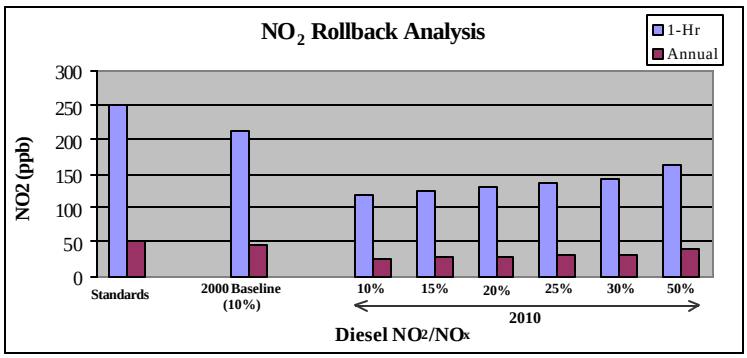


Corroborative Analyses

- Air quality modeling of trap effects in Central California:
  - Shows similar effects
  - No ozone benefits at low NO_2/NO_x
  - Less response to winter NO_2 increases
  - No PM analysis
- UC Irvine modeling results for ozone, nitric acid, NO_2:
  - Relative changes consistent with results presented today

Corroborative Analyses
(cont.)

- NO_2 rollback:
  - Ignores Banning Airport - high levels related to interference from local nitric acid source



Summary of Impacts

Diesel NO_2/NO_x	15%	20%	25%	30%	50%
SUMMER	**% change** from baseline (diesel NO_2/NO_x = 10%)				
Peak 1-Hr O_3	**-1**	**0**	**0**	**0**	1
24-Hr O_3 Exposure > 90 ppb	**-3**	**-2**	**0**	2	5
Peak 24-Hr HNO_3	**0**	1	1	1	2
24-Hr HNO_3 Exposure	**0**	**0**	2	2	4
Peak 24-Hour $PM_{2.5}$	**-3**	N/A	N/A	**-2**	**-1**
24-Hour $PM_{2.5}$ Exposure > 65 ug/m^3	**-9**	N/A	N/A	**-8**	**-6**
FALL					
Peak 24-Hour $PM_{2.5}$	**-6**	N/A	N/A	**-5**	**-3**
24-Hour $PM_{2.5}$ Exposure > 65 ug/m^3	**-13**	N/A	N/A	**-13**	**-13**
WINTER					
Peak 1-Hr NO_2	1	6	12	18	41

Numbers in **bold** represent simulated air quality benefits or no change

Summary of Impacts
(cont.)

- For modest increases in diesel NO_2 (diesel NO_2/NO_x ~20-25%):
  - Ozone:
    - Air quality benefits or no change in both peak 1-hour and 24-hour exposure indicators
  - Nitric acid:
    - ~1% increase in 24-hour peak, max. 2% increase in exposure
    - No standard; short-term health implications of small increases unlikely; long-term health implications unclear
  - NO_2:
    - 6-12% increases
    - Rollback analysis estimates no exceedances of standard
  - $PM_{2.5}$:
    - Air quality benefits for all scenarios
    - Direct reduction in diesel PM provides reductions in ambient cancer risk

Conclusions

- These results supercede the previously presented preliminary analysis:
  - Updated emissions assumptions
  - More rigorous analysis
- A modest increase in the diesel NO_2 fraction has more benefits than disbenefits

THE END